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TITLE: CUTTING TOOL AND ITS MANUFACTURE

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ABSTRACT:

PROBLEM TO BE SOLVED: To provide a cutting tool excellent in abrasion resistance etc., and a manufacturing method therefor.

SOLUTION: This cutting tool contains silicon nitride as a matrix, 10-20 wt.% titanium nitride, 3-5 wt.% alumina, and 5-15 wt.% yttria, and has a matrix phase consisting of the silicon nitride, a hard phase consisting of the titanium nitride, a glass phase existing in a grain boundary phase, and a crystal phase existing in the grain boundary phase. A ratio R(=B/A) of a maximum peak A of the silicon nitride by X-ray diffraction to a maximum peak B

of the crystal phase other than the silicon nitride and the titanium nitride by X-ray diffraction is in the range of 0.05

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(54)【発明の名称】　切削工具及びその製造方法

(57)【要約】

【課題】　耐摩耗性等に優れた切削工具及びその製造方法を提供すること。

【解決手段】　窒化珪素をマトリックスとして、窒化チタン：１０～２０重量%、アルミナ：３～５重量%、イットリア：５～１５重量%を含有する切削工具であって、窒化珪素からなるマトリックス相、窒化チタンからなる硬質相、粒界相に存在するガラス相、及び粒界相に存在する結晶相を備えるとともに、Ｘ線回折による、窒化珪素の最大ピークＡと、窒化珪素及び窒化チタン以外の結晶相の最大ピークＢとの比Ｒ（＝Ｂ／Ａ）が、０．０５≦Ｒ≦０．６の範囲である切削工具。

【特許請求の範囲】

【請求項１】　窒化珪素をマトリックスとして、窒化チタン：１０～２０重量%、アルミナ：３～5重量%、イットリア：5～１５重量%を含有する切削工具であって、
前記窒化珪素からなるマトリックス相、前記窒化チタンからなる硬質相、粒界相に存在するガラス相、及び前記粒界相に存在する結晶相を備えるとともに、
Ｘ線回折による、前記窒化珪素の最大ピークＡと、前記窒化珪素及び窒化チタン以外の前記結晶相の最大ピークＢとの比Ｒ（＝Ｂ／Ａ）が、０．０５≦Ｒ≦０．６の範囲であることを特徴とする切削工具。

【請求項２】　前記結晶相には、Ｊ相を含むことを特徴とする前記請求項１に記載の切削工具。

【請求項３】　前記切削工具は、超耐熱合金の切削加工用であることを特徴とする前記請求項１又は２に記載の切削工具。

【請求項４】　前記切削工具は、すくい面と逃げ面との間に切れ刃を有することを特徴とする前記請求項１～３のいずれかに記載の切削工具。

【請求項５】　前記請求項１～４のいずれかに記載の切削工具の製造方法であって、
窒素雰囲気中で、常圧焼結を行うことを特徴とする切削工具の製造方法。

【請求項６】　前記常圧焼結後に、窒素雰囲気中でガス圧焼結を行うことを特徴とする前記請求項５に記載の切削工具の製造方法。

【請求項７】　前記常圧焼結後に、ＨＩＰによる焼結を行うことを特徴とする前記請求項５に記載の切削工具の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、窒化珪素をマトリックスとする切削工具及びその製造方法に関するものである。

【０００２】

【従来の技術】従来より、窒化珪素をマトリックス（母材）とする多くの焼結体が開発されている。例えば特公昭６０－４８４７５号公報には、窒化チタン、窒化タンタルから選ばれる１種又は２種を含有する窒化珪素ホットプレス焼結体が提案されている。

【０００３】また、これとは別に、特開平９－２６８０７１号公報には、窒化珪素と炭窒化チタンを主体とする窒化珪素工具が開示されており、この種の窒化珪素工具は、鋳鉄部品の加工（切削加工）などに使用されている。

【０００４】

【発明が解決しようとする課題】ところで、上述した窒化珪素工具は、鋳鉄部品の切削加工以外に、超耐熱合金の切削加工にも用いられるが、超耐熱合金は熱伝導性が悪いので、工具刃先に熱がこもり易いという問題があった。

【０００５】つまり、刃先温度が上昇すると、工具を構成する組織の各相（マトリックス相、硬質相、粒界相）のうち、粒界相の軟化が進み、工具の耐摩耗性が低下するという問題があった。本発明は上記問題点に鑑みて提案されたものであり、耐摩耗性等に優れた切削工具及びその製造方法を提供することを目的とする。

【０００６】

【課題を解決するための手段】（１）前記目的を達成するための請求項１の発明は、窒化珪素をマトリックスとして、窒化チタン：１０～２０重量%、アルミナ：３～5重量%、イットリア：5～１５重量%を含有する切削工具であって、前記窒化珪素からなるマトリックス相、前記窒化チタンからなる硬質相、粒界相に存在するガラス相、及び前記粒界相に存在する結晶相を備えるとともに、Ｘ線回折による、前記窒化珪素の最大ピークＡと、前記窒化珪素及び窒化チタン以外の前記結晶相の最大ピークＢとの比Ｒ（＝Ｂ／Ａ）が、０．０５≦Ｒ≦０．６の範囲であることを特徴とする切削工具を要旨とする。

【０００７】①本発明の切削工具は、窒化珪素をマトリックス（即ち主成分である母材）とする窒化珪素質焼結体であり、この窒化珪素以外に、窒化チタン：１０～２０重量%、アルミナ：３～5重量%、イットリア：5～１５重量%を含んでいるが、特に、窒化珪素のマトリックスに、熱伝導性に優れ且つ摩擦係数の少ない窒化チタンを含有させて複合化することにより、耐摩耗性が増加するという効果が得られる。

【０００８】以下、各成分の数値限定の理由を説明する。

<窒化チタン：１０～２０重量%>溶融金属に対する耐摩耗性が高い窒化チタンの含有量が１０重量%を下回ると、耐摩耗性の向上が十分ではなく、一方、２０重量%を上回ると、焼結性が低下する傾向があるので、窒化チタンは、１０～２０重量%が最も好ましい範囲である。

【０００９】<アルミナ：３～5重量%>アルミナの含有量が３重量%を下回ると、焼結性が低下し、一方、5重量%を上回ると、硬度が低下し、耐摩耗性が劣化するので、アルミナは、３～5重量%が最も好ましい範囲である。

【００１０】<イットリア：5～１５重量%>イットリアの含有量が5重量%を下回ると、焼結性が低下し、一方、１５重量%を上回ると、結晶相が多くなるので、イットリアは、5～１５重量%が最も好ましい範囲である。

【００１１】尚、切削工具が、実質的に、窒化珪素、窒化チタン、アルミナ、イットリアのみからなる場合には、窒化珪素の重量%は、窒化チタン、アルミナ、イットリアの合計重量%の残部となる。

②また、本発明では、前記組成の構成に加えて、４種の

相構造を有している。つまり、窒化珪素からなるマトリックス相（母材相）、窒化チタンからなる硬質相、粒界相に存在するガラス相、及び粒界相に存在する結晶相である。この４相の状態を、図１に模式的に示すが、マトリックス相と硬質相との間に粒界相が存在し、この粒界相がガラス相と結晶相とから構成されている。

【００１２】本発明では、この粒界相の一部の結晶化による結晶相の存在により、粒界相におけるガラス相量が減少するので、刃先温度が上昇した場合でも、粒界相の軟化が低減されることになり、結果として、耐摩耗性が向上するという効果が得られる。

【００１３】③更に、本発明では、Ｘ線回折によって得られた、窒化珪素の最大ピークＡと、窒化珪素及び窒化チタン以外の結晶相の最大ピークＢとの比Ｒ（＝Ｂ／Ａ）が、０．０５≦Ｒ≦０．６の範囲に設定されている。尚、結晶相におけるピークとは、結晶相に含まれる、例えば、$Y_8Si_4N_4O_{14}$、$Y_{10}Al_2Si_3O_{18}N_4$、$Y_{10}Si_7N_4O_{23}$の様な既知の結晶や未知の結晶の量を示すものである。

【００１４】そして、前記ピークの比Ｒが、０．０５を下回ると、結晶相の量が少なすぎて、前記粒界相の軟化を抑制する効果が少なく、耐摩耗性が低い。一方、ピークの比Ｒが０．６を上回ると、結晶相の量が多すぎて、靭性が低下する。よって、前記ピークの比Ｒは、０．０５≦Ｒ≦０．６が最も好ましい範囲である。

【００１５】つまり、本発明は、上述した４成分の組成、４種の相の構成、及びピークの比Ｒを備えているので、耐摩耗性及び靭性に優れた切削工具である。

（２）請求項２の発明は、前記結晶相には、Ｊ相を含むことを特徴とする前記請求項１に記載の切削工具を要旨とする。

【００１６】本発明は、結晶相の構成を例示したものであり、結晶相としてＪ相、即ち$Y_8Si_4N_4O_{14}$を含んでいる。よって、粒界相のガラス相が減少して、融点の高い結晶となるため、高温での粒界相の軟化が抑制されるという効果がある。

（３）請求項３の発明は、前記切削工具は、超耐熱合金の切削加工用であることを特徴とする前記請求項１又は２に記載の切削工具を要旨とする。

【００１７】本発明は、切削工具の用途を例示したものである。つまり、超耐熱合金は熱伝導性が悪く、切削工具の刃先に熱がこもりやすいが、本発明では、上述した構成を備えているので、超耐熱合金を切削加工する際に刃先温度が上昇した場合でも、粒界相の軟化が抑制され、優れた耐摩耗性を発揮できる。

【００１８】ここで、超耐熱合金とは、通常、６５０℃以上の高温での使用に耐える合金であり、具体的には、合金組成のＦｅ成分が５０重量％以下の合金とＮｉ、Ｃｏ系のものを主成分とする高温用の合金等のことである。この超耐熱合金としては、例えばＮｉ基合金のインコネル、ワスパロイなどが挙げられる。

【００１９】尚、本発明の切削工具は、上述したＮｉ基合金（インコネル、ワスパロイ）を切削するのに特に好ましいものである。この切削条件としては、下記の範囲が好適である。

切削速度　：Ｖ＝１００～５００ｍ／ｍｉｎ（より好ましくは、２００～４００ｍ／ｍｉｎ）

送り量　　：ｆ＝０．０５～０．４ｍｍ／ｒｅｖ（より好ましくは、０．１～０．３ｍｍ／ｒｅｖ）

切込み　　：ｄ＝０．０５ｍｍ以上（より好ましくは、０．１ｍｍ以上）

（４）請求項４の発明は、前記切削工具は、すくい面と逃げ面との間に切れ刃を有することを特徴とする前記請求項１～３のいずれかに記載の切削工具を要旨とする。

【００２０】本発明は、切削工具の形状を例示したものであり、すくい面と逃げ面との間に切れ刃を備えた例えば直方体形状が挙げられる。また、それ以外にも、すくい面側がひし形の四角柱形状、すくい面側が三角形の三角柱形状、すくい面側が円形の円柱形状など、各種の形状のものが挙げられる。

【００２１】（５）請求項５の発明は、前記請求項１～４のいずれかに記載の切削工具の製造方法であって、窒素雰囲気中で、常圧焼結を行うことを特徴とする切削工具の製造方法を要旨とする。本発明は、切削工具の製造方法を例示したものであり、ここでは、前記切削工具の組成等の構成となるように調整した材料を成形し、窒素雰囲気中で常圧焼結することにより、窒化珪素質焼結体を製造することができるので、その後、例えば研磨等の後加工を施すことにより、切削工具とすることができる。

【００２２】この常圧焼結は、例えばＨＩＰに比べて製造が容易で、製造コストが低く、そのため、低いコストで切削工具を製造できるという利点がある。尚、常圧焼結のみで、切削工具に適した窒化珪素質焼結体を製造する場合には、その材料の組成（従って切削工具の組成）を適切に選択する必要がある。具体的には、切削工具の組成が、例えばＴｉＮ：１０重量％以下、焼結助剤：６重量％以上、残部：Si_3N_4となる様な材料を選択することが望ましい。

【００２３】（６）請求項６の発明は、前記常圧焼結後に、窒素雰囲気中でガス圧焼結を行うことを特徴とする前記請求項５に記載の切削工具の製造方法を要旨とする。特定の組成以外の場合には、通常、常圧焼結（一次焼結）のみでは、切削工具として十分に緻密化した焼結体が得られ難いので（例えば理論密度比の９５％以下）、本発明では、二次焼結として、窒素雰囲気中でガス圧焼結を行う。これにより、十分に緻密化した焼結体が得られる（例えば理論密度比９８％以上）。

【００２４】この様に、常圧焼結とガス圧焼結とを組み合わせることにより、十分に緻密化した焼結体を低コス

トで製造することができる。尚、ガス圧焼結の条件としては、窒素雰囲気が採用されるが、その窒素雰囲気の圧力は5～100気圧、焼成温度は1600～1800℃の範囲が望ましい。

【0025】（7）請求項7の発明は、前記常圧焼結後に、HIP（Hot Isostatic Press：熱間静水圧プレス）による焼結を行うことを特徴とする前記請求項5に記載の切削工具の製造方法を要旨とする。

【0026】上述した様に、通常、常圧焼結（一次焼結）のみでは、切削工具として十分に緻密化した焼結体が得られ難いので、本発明では、二次焼結として、HIPによる焼結を行う。これにより、十分に緻密化した焼結体が得られる（理論密度比95％以上）。

【0027】この様に、常圧焼結とHIPによる焼結とを組み合わせることにより、十分に緻密化した焼結体を製造することができる。尚、HIPによる焼結の条件としては、窒素雰囲気が採用されるが、その窒素雰囲気の圧力は1000～2000気圧、焼成温度は1500～1800℃の範囲が望ましい。

【0028】

【発明の実施の形態】以下、本発明の切削工具及びその製造方法の実施の形態の例（実施例）を、図面を参照して説明する。

（実施例）本実施例では、超耐熱合金の切削加工用に用いられる窒素珪素質焼結体からなる切削工具及びその製造方法を例に挙げる。

【0029】a）まず、本実施例の切削工具について説明する。図2に示す様に、本実施例の切削工具1は、ISO規格：SNGN120408形状のネガチップである。具体的には、切削工具1は、図2の上下方向のすくい面3、側面側の四方の逃げ面5、及びすくい面3と逃げ面5の間の各辺である切れ刃7を備えており、切れ刃7の長さが各々12．7mm、切削工具1の厚さが4．76mmの直方体のチップである。尚、切れ刃7には、面取り加工（チャンファー加工）が施されている。

【0030】また、本実施例の切削工具1は、窒化珪素をマトリックス（母材）とする窒化珪素質焼結体からなり、窒化チタン：10～20重量％、アルミナ：3～5重量％、イットリア：5～15重量％、窒化珪素：残部の組成を有している。更に、この切削工具1は、窒化珪素からなるマトリックス相、窒化チタンからなる硬質相、粒界相に存在するガラス相、及び粒界相に存在する結晶相を備えるとともに、X線回折による、窒化珪素の最大ピークAと、窒化珪素及び窒化チタン以外の結晶相の最大ピークBとの比R（＝B／A）が、0．05≦R≦0．6の範囲の工具である。

【0031】b）次に、本実施例の切削工具1の製造方法について説明する。平均粒径0．5μmの主成分の窒化珪素（Si_3N_4）粉末（α率＝99％以上）と、平均粒径0．8μmのイットリア（Y_2O_3）粉末と、平均粒

径0．4μmのアルミナ（Al_2O_3）粉末とを、前記切削工具1の組成範囲となる様に、下記表1に示す配合割合（本発明例）に秤量する。

【0032】次に、この秤量した材料を、アルミナ製ボール、アルミナ製内壁ポットを用いて、エタノール溶媒中にて16時間湿式混合粉砕し、スラリーとする。次に、このスラリーを、湯煎乾燥し、エタノールに溶解したマイクロワックス系の有機バインダを固形分比で3．5重量％添加し、ライカイ機で混合する。

【0033】次に、得られた素地を、ISO規格：SNGN120408形状になるようにプレス成形した後、1気圧に設定された窒素雰囲気中で、800℃で60分加熱して脱ワックスを行う。次に、1次焼結を行う。この1次焼結は、常圧（1気圧）の窒素雰囲気中で、1700℃で4時間加熱して、焼結を行うものである。

【0034】次に、ガス圧焼結により2次焼結を行う。この2次焼結は、75気圧に設定された窒素雰囲気中で、1750℃で4時間加熱して、焼結を行うものであるの尚、この2次焼結のガス圧焼結に代えて、HIPによる焼結を行ってもよい。このHIPによる2次焼結は、1000気圧に設定された窒素雰囲気中にて、1700℃で4時間加熱して、焼結を行うものである。

【0035】次に、この様にして得られた窒化珪素質焼結体を、下記表1に示す様な条件（本発明例）で、窒素雰囲気中で熱処理し、粒界相の結晶化を促進する。次に、この窒化珪素焼結体を、ISO規格：SNGN120408形状に研削加工することにより、切削工具1を完成する。

【0036】c）次に、本発明の範囲の切削工具の効果を確認するために行った実験例について説明する。まず、実験に用いる切削工具として、下記表1に示す条件にて、本発明例（試料No.1～4）及び比較例（試料No.5～10）の切削工具を作製した。尚、切削工具の形状は、ISO規格：SNGN120408である。

【0037】そして、これらの試料No.1～10の切削工具に対して、下記(i)物理性能評価及び(ii)切削性能評価を行った。

(i)＜物理性能評価＞

下記の様にして、焼結体の密度、マイクロポア、硬度、靭性、ピーク比R（結晶相量）、結晶相の種類を求めた。その結果を下記表1に記す。

【0038】①（密度）

アルキメデス法で焼結体の密度を測定した。そして、その密度から、焼結体の理論密度比を求めた。また、マイクロポアは、焼結体断面を鏡面研磨し、200倍の顕微鏡で観察し、CIS－006B規格により測定した。

【0039】②（硬度及び靭性）

焼結体の研削した面を鏡面研磨し、30kgの押し込み荷重でビッカース圧子を押し込み、圧痕の対角長さと亀裂長さを測定し、ビッカース硬度（JIS R1610

に準拠）と破壊靭性値（ＪＩＳ　Ｒ１６０７（ＩＦ法）に準拠）を求めた。

【００４０】③（ピーク比Ｒ（結晶相量））
焼結体の研磨面に対するＸ線回折を行って、そのピーク比Ｒを求めた。例えば図３に示す様なＸ線回折が得られた場合には、窒化珪素の最大ピークＡ（＝Ｉ（Si_3N_4 max））と、窒化珪素及び窒化チタン以外の結晶相の最大ピークＢ（＝Ｉ（GB max））とを測定し、そのピーク比Ｒ（＝Ｂ／Ａ＝Ｉ（GB max）／Ｉ（Si_3N_4 max））を求める。

【００４１】尚、図３は縦軸に強度［ｃｐｓ］をとり、横軸に２θ［°］をとったＸ線回折の結果のグラフであり、図３では、ピーク比Ｒは、０．４８である。

④（結晶相の種類）
また、前記Ｘ線回折によって得られた各ピークを、既知の材料のピークと対比させて調べることにより、結晶相＊＊の種類を調べた。

【００４２】(ii)<切削性能評価>
図４に示す様に、下記の条件にて、回転する円柱形状の被削材の外径側の表面に対して、切削工具を矢印Ａ方向に移動させて旋削を行った。そして、その際の工具刃先の摩耗状態（１パス後のフランク摩耗量）やカケの発生状況を調べた。その結果を、下記表１に記す。

【００４３】（切削条件）
被削材材質：インコネル７１８
被削材形状：外径φ３００ｍｍ×長さ１００ｍｍ
切削速度　：Ｖ＝３００ｍ／ｍｉｎ
送り量　　：ｆ＝０．１５ｍｍ／ｒｅｖ
切込み　　：ｄ＝１．０ｍｍ
乾湿　　　：ＷＥＴ

【００４４】
【表１】

		本発明品				比較例					
試料No.		1	2	3	4	5	6	7	8	9	10
配合組成［重量%］	Si_3N_4	83	75	70.5	60	88	55	75	75	85	68
	Al_2O_3	3	5	3.5	5	3	5	5	5	2	6
	Y_2O_3	4	5	11	15	4	15	5	5	3	16
	TiN	10	15	15	20	5	25	15	15	10	10
焼結方法		①	①＋②	①＋②	①＋③	①	①＋③	①	①	①	①
焼結体の構成相	Si_3N_4	○	○	○	○	○	○	○	○	○	○
	TiN	○	○	○	○	○	○	○	○	○	○
	結晶相	J, A Uk	J Uk	J Uk	J, H Uk	J Uk	J Uk	J Uk	J Uk	J, A Uk	J Uk
	ピーク比Ｒ	0.07	0.3	0.45	0.52	0.3	0.3	0.02	0.7	0.06	0.55
物理特性	理論密度比	99.7	99.6	99.8	99	99.6	99.8	99.6	99.8	94	99.8
	マイクロポア	A2	A2	A2	A2	A2	A2	A2	A2	A8	A2
	硬度Ｈｖ	15.5	15.5	15	14.8	16	14	15	16.5	14.0	14
	靭性Ｋｃ	6.8	6.2	6.7	6	7.3	5.2	6.2	5	5.0	6.5
切削性能	摩耗量［ｍｍ］	0.3	0.2	0.1	0.1	1.6	チッピング	0.8	チッピング	カケ	0.9

【００４５】尚、前記表１で、焼結体の構成相において、Si_3N_4の○はマトリックス相の存在を示し、ＴｉＮの○は硬質相の存在を示す。また、結晶相のＪ相を示すＪは$Y_8Si_4N_4O_{14}$、Ａ相を示すＡは$Y_{10}Al_2Si_3O_{18}N_4$、Ｈ相を示すＨは$Y_{10}Si_7N_4O_{23}$、Ｕｋは未知相である。

【００４６】更に、焼結方法の①は常圧焼結、②はガス圧焼結、③はＨＩＰであり、＋で示すものは、１次焼結に加えて２次焼結を行うものである。尚、試料No.７の焼結方法においては、急速冷却を行い、試料No.８の焼結方法では、１４００℃で窒素１気圧中１２時間保持の熱処理を行った。

【００４７】また、マイクロポアのＡ２はマイクロポア０．０２体積％を示し、Ａ８はマイクロポア０．６体積％を示す。この表１から明かな様に、本発明例である窒化チタンを所定量含み所定ピーク比Ｒの結晶相を有する試料No.１～４は、耐摩耗性に優れている。また、試料No.１～４は、適度な硬度と靭性を備えており、実験の際に、チッピングが発生せず、好適である。

※【００４８】それに対して、窒化チタンが少な過ぎると（比較例試料No.５）、摩耗量が多く、また、窒化チタンが多すぎると（比較例試料No.６）、硬くなって脆くなり、刃先がチッピングするので、好ましくない。また、粒界相の結晶化が少なすぎると（比較例試料No.７）、摩耗が多くなり、逆に、結晶化が多すぎると（比較例試料No.８）、靭性が不足して、チッピングに到るので、好ましくない。

【００４９】更に、焼結助剤が少ないと（比較例試料No.９）、９４％しか緻密化せず、焼結助剤が多いと（比較例試料No.１０）、耐摩耗性が悪いので、好ましくない。尚、本発明は前記実施例になんら限定されるものではなく、本発明の要旨を逸脱しない範囲において種々の態様で実施しうることはいうまでもない。

【００５０】
【発明の効果】以上詳述した様に、本発明の切削工具は、上述した４成分の組成、４種の相の構成、及びピークの比Ｒを備えているので、即ち、窒化珪素と窒化チタンの適度な複合化及び粒界相の適度な結晶化により、耐

摩耗性及び靭性に優れた切削工具である。

【００５１】また、本発明の切削工具の製造方法により、上述した優れた性能を有する切削工具を、低コストで容易に製造することができる。

【図面の簡単な説明】

【図１】　切削工具を構成する各相の状態を模式的に示す説明図である。

【図２】　実施例１の切削工具の形状を示す斜視図である。

【図３】　Ｘ線回折によるピークの状態を示す説明図である。

【図４】　切削性能評価の方法を示す説明図である。

【符号の説明】

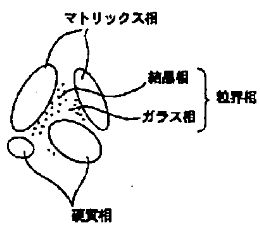
１…切削工具

３…すくい面

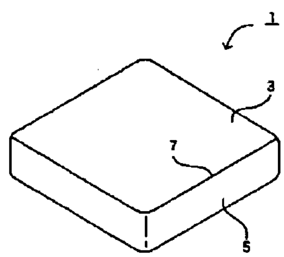
５…逃げ面

７…切れ刃

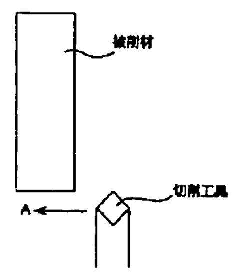
【図１】



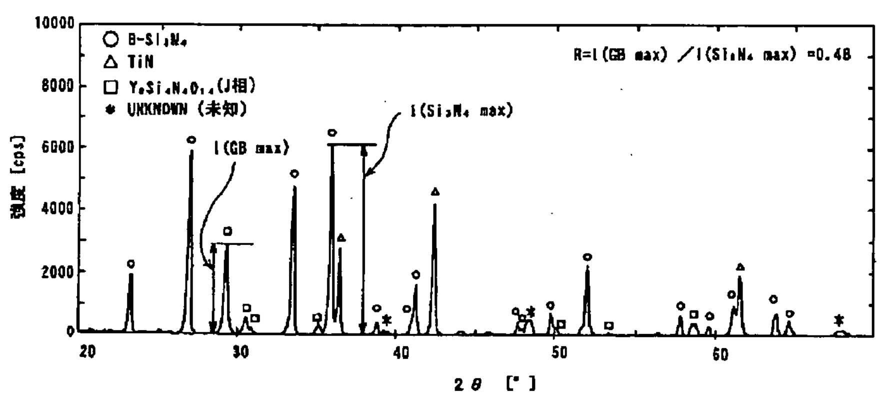
【図２】



【図４】



【図３】



DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the cutting tool which makes a silicon nitride a matrix, and its manufacture method.
[0002]
[Description of the Prior Art] Conventionally, many sintered compacts which make a silicon nitride a matrix (base material) are developed. For example, the silicon-nitride hotpress sintered compact containing one sort chosen from a titanium nitride and a tantalum nitride or two sorts is proposed by JP,60-48475,B.
[0003] Moreover, apart from this, the silicon nitride tool which makes a silicon nitride and a charcoal titanium nitride a subject is indicated by JP,9-268071,A, and this kind of silicon nitride tool is used for processing (cutting) of cast iron parts etc.
[0004]
[Problem(s) to be Solved by the Invention] By the way, although the silicon nitride tool mentioned above was used also for cutting of a superalloy in addition to cutting of cast iron parts, since thermal conductivity of the superalloy was bad, there was a problem that the tool edge of a blade tends to be filled with heat.
[0005] That is, when edge-of-a-blade temperature rose, softening of a grain-boundary phase progressed among each phase (a matrix phase, a hard phase, grain-boundary phase) of the organization which constitutes a tool, and there was a problem that the abrasion resistance of a tool fell. this invention is proposed in view of the above-mentioned trouble, and it aims at offering the cutting tool excellent in abrasion resistance etc., and its manufacture method.
[0006]
[Means for Solving the Problem] (1) Invention of the claim 1 for attaining the aforementioned purpose A silicon nitride is made into a matrix. Titanium-nitride:10-20 % of the weight, alumina:3-5 % of the weight, Yttria : while having the matrix phase which is a cutting tool containing 5 - 15 % of the weight, and consists of the aforementioned silicon nitride, the hard phase which consists of the aforementioned titanium nitride, the glass phase which exists in a grain-boundary phase, and the crystal phase which exists in the aforementioned grain-boundary phase a ratio with the maximum peak B of the aforementioned crystal phases other than the maximum peak A of the aforementioned silicon nitride by the X diffraction, the aforementioned silicon nitride, and a titanium nitride -- R (=B/A) makes a summary the cutting tool characterized by being the range of 0.05<=R<=0.6
[0007] ** Although the cutting tool of this invention is a nature sintered compact of a silicon nitride which makes a silicon nitride a matrix (namely, base material which is a principal component) and titanium-nitride:10-20 % of the weight, alumina:3-5 % of the weight, and yttria:5-15 % of the weight are included in addition to this silicon nitride, the effect that abrasion resistance increases to the matrix of a silicon nitride especially by excelling in thermal conductivity, and making a titanium nitride with little coefficient of friction contain, and composite-izing is acquired.

[0008] Hereafter, the reason of numerical limitation of each component is explained.
< titanium nitride: If the content of a titanium nitride with the high abrasion resistance to 10 - 20 % of the weight > molten metal is less than 10 % of the weight, wear-resistant improvement is not enough, and since there is an inclination for a degree of sintering to fall, on the other hand when it exceeds 20 % of the weight, a titanium nitride is a range with 10 - 20 most desirable % of the weight.
[0009] < alumina: Since a degree of sintering will fall if the content of a 3 - 5 % of the weight > alumina is less than 3 % of the weight, a degree of hardness will fall on the other hand if it exceeds 5 % of the weight, and abrasion resistance deteriorates, an alumina is a range with 3 - 5 most desirable % of the weight.
[0010] < yttria: If it exceeds 15 % of the weight, since a degree of sintering will fall if the content of a 5 - 15 % of the weight > yttria is less than 5 % of the weight, and a crystal phase will increase on the other hand, a yttria is a range with 5 - 15 most desirable % of the weight.
[0011] In addition, when a cutting tool consists only of a silicon nitride, a titanium nitride, an alumina, and a yttria substantially, weight % of a silicon nitride becomes a titanium nitride, an alumina, and the remainder of sum total weight % of a yttria.
** In addition to the composition of the aforementioned composition, by this invention, it has four sorts of phase structures again. That is, they are the matrix phase (base material phase) which consists of a silicon nitride, the hard phase which consists of a titanium nitride, the glass phase which exists in a grain-boundary phase, and the crystal phase which exists in a grain-boundary phase. Although the state of these four phases is typically shown in drawing 1 , a grain-boundary phase exists between a matrix phase and a hard phase, and this grain-boundary phase consists of a glass phase and a crystal phase.
[0012] In this invention, since the amount of glass phases in a grain-boundary phase decreased, even when edge-of-a-blade temperature rises by existence of the crystal phase by crystallization of a part of this grain-boundary phase, softening of a grain-boundary phase will be reduced and the effect that abrasion resistance improves is acquired as a result.
[0013] ** a ratio with the maximum peak B of crystal phases other than the maximum peak A of a silicon nitride further acquired according to the X diffraction by this invention, a silicon nitride, and a titanium nitride -- R (=B/A) is set as the range of 0.05<=R<=0.6 In addition, the peak in a crystal phase is included in a crystal phase, for example, shows the amount of a known crystal like [Y8Si4N 4O14 and 3O18Ns of Y10aluminum2Si] 4 and Y10Si7N 4O23, or a strange crystal.
[0014] and the ratio of the aforementioned peak -- the effect that there will be too few amounts of a crystal phase and they will suppress softening of the aforementioned grain-boundary phase if R is less than 0.05 -- few -- abrasion resistance -- a low On the other hand, if the ratio R of a peak exceeds 0.6, there will be too many amounts of a crystal phase and toughness will fall. therefore, the ratio of the aforementioned peak -- R is a range with most desirable 0.05<=R<=0.6
[0015] that is, composition of four components which mentioned this invention above, the composition of four sorts of phases, and the ratio of a peak -- since it has R, it is the cutting tool excellent in abrasion resistance and toughness
(2) Invention of a claim 2 makes [the aforementioned crystal phase] the cutting tool of a publication a summary at the aforementioned claim 1 characterized by including J phase.
[0016] this invention illustrates the composition of a crystal phase and contains J phase, i.e., Y8Si, 4N 4O14 as a crystal phase. Therefore, since the glass phase of a grain-boundary phase decreases and it becomes the high crystal of the melting point, it is effective in softening of the grain-boundary phase in an elevated temperature being suppressed.
(3) Invention of a claim 3 makes a summary the aforementioned claim 1 characterized by the aforementioned cutting tool being an object for cutting of a superalloy, or a cutting tool given in 2.
[0017] this invention illustrates the use of a cutting tool. That is, by this invention, although thermal conductivity of a superalloy is bad and the edge of a blade of a cutting tool tends to be filled with heat, since it has the composition mentioned above, even when carrying out cutting of the superalloy and edge-of-a-blade temperature rises, softening of a grain-boundary phase is suppressed and the outstanding abrasion resistance can be demonstrated.

[0018] Here, a superalloy is usually an alloy which is equal to the use in an elevated temperature of 650 degrees C or more, and, specifically, are things, such as an alloy of a high temperature service with which Fe component of alloy composition makes a principal component the thing of alloy [50 or less % of the weight of], nickel, and Co system. As this superalloy, the Inconel of nickel machine alloy, WASUPAROI, etc. are mentioned, for example.
[0019] In addition, the cutting tool of this invention is especially desirable although nickel machine alloy (an Inconel, WASUPAROI) mentioned above is cut. As these cutting conditions, the following range is suitable.
Cutting speed : V= 100 - 500 m/min (preferably 200 - 400 m/min)
Feed per revolution : f= 0.05 - 0.4 mm/rev (preferably 0.1 - 0.3 mm/rev)
Infeed : d= 0.05mm or more (preferably 0.1mm or more)
(4) Let the cutting tool of a publication be a summary at either of the aforementioned claims 1-3 to which invention of a claim 4 is characterized by the aforementioned cutting tool having a cutting edge between a rake face and a flank.
[0020] this invention illustrates the configuration of a cutting tool and for example, the rectangular parallelepiped configuration equipped with the cutting edge between the rake face and the flank is mentioned. Moreover, the thing of various kinds of configurations, such as the shape of a square pilaster of a rhombus and the shape of a cylindrical shape with a circular rake face side triangular triangle pole configuration and rake face side, is mentioned for a rake face side besides it.
[0021] (5) Invention of a claim 5 is the manufacture method of a cutting tool given in either of the aforementioned claims 1-4, and makes a summary the manufacture method of the cutting tool characterized by performing ordinary-pressure sintering in nitrogen atmosphere. Since this invention can manufacture the nature sintered compact of a silicon nitride by illustrating the manufacture method of a cutting tool, fabricating the material adjusted here so that it might become the composition of composition of the aforementioned cutting tool etc., and carrying out ordinary-pressure sintering in nitrogen atmosphere, let it be a cutting tool by performing post processing, such as after that, for example, polish etc.
[0022] This ordinary-pressure sintering has the advantage that manufacture is easy compared with HIP and a cutting tool can be manufactured at cost with it. [a low therefore manufacturing cost and] [low] In addition, when manufacturing the nature sintered compact of a silicon nitride suitable for the cutting tool only by ordinary-pressure sintering, it is necessary to choose appropriately composition (therefore, composition of a cutting tool) of the material. It is desirable to specifically choose material from which composition of a cutting tool serves as less than [TiN:10 % of the weight], more than sintering-acid:6 % of the weight, and remainder:Si3N4.
[0023] (6) Let the manufacture method of the cutting tool a publication be a summary at the aforementioned claim 5 characterized by invention of a claim 6 performing gas ****** in nitrogen atmosphere after the aforementioned ordinary-pressure sintering. cases other than specific composition -- usually -- ordinary-pressure sintering (primary sintering) -- accepting it -- coming out -- as a cutting tool -- enough -- precise-izing -- since a sintered compact is hard to be obtained the bottom (for example, 95% or less of a theoretical density ratio), in this invention, gas ****** is performed in nitrogen atmosphere as secondary sintering Thereby, the sintered compact which fully turned precisely is obtained (for example, a theoretical density ratio 98% or more).
[0024] Thus, the sintered compact which fully turned precisely can be manufactured by the low cost by combining ordinary-pressure sintering and gas ******. In addition, as conditions for gas ******, although nitrogen atmosphere is adopted, the pressure of the nitrogen atmosphere is five to 100 atmospheric pressure, and the range of burning temperature of 1600-1800 degrees C is desirable.
[0025] (7) Let the manufacture method of the cutting tool a publication be a summary at the aforementioned claim 5 characterized by invention of a claim 7 performing sintering by HIP (Hot Isostatic Press : hot isostatic press) after the aforementioned ordinary-pressure sintering.
[0026] it mentioned above -- as -- usually -- ordinary-pressure sintering (primary sintering) -- accepting it -- coming out -- as a cutting tool -- enough -- precise-izing -- since a sintered compact is hard to be

obtained the bottom, in this invention, sintering by HIP is performed as secondary sintering Thereby, the sintered compact which fully turned precisely is obtained (theoretical density ratio 95% or more).
[0027] Thus, the sintered compact which fully turned precisely can be manufactured by combining ordinary-pressure sintering and sintering by HIP. In addition, as conditions for sintering by HIP, although nitrogen atmosphere is adopted, the pressure of the nitrogen atmosphere is 1000 to 2000 atmospheric pressure, and the range of burning temperature of 1500-1800 degrees C is desirable.
[0028]
[Embodiments of the Invention] Hereafter, the example (example) of the cutting tool of this invention and the gestalt of operation of the manufacture method is explained with reference to a drawing.
(Example) In this example, the cutting tool which consists of a nature sintered compact of nitrogen silicon used for cutting of a superalloy, and its manufacture method are mentioned as an example.
[0029] a) Explain the cutting tool of this example first. As shown in drawing 2 , the cutting tool 1 of this example is the negative chip of ISO specification:SNGN120408 configuration. Specifically, the cutting tool 1 is equipped with the cutting edge 7 which is each side between the rake face 3 of the vertical direction of drawing 2 , the flank 5 of the four way type by the side of the side, and a rake face 3 and a flank 5, and the length of a cutting edge 7 is the chip of the rectangular parallelepiped whose thickness of 12.7mm and a cutting tool 1 is 4.76mm respectively. In addition, beveling processing (chamfer processing) is given to the cutting edge 7.
[0030] Moreover, the cutting tool 1 of this example consists of a nature sintered compact of a silicon nitride which makes a silicon nitride a matrix (base material), and has composition of the silicon-nitride:remainder titanium-nitride:10-20 % of the weight, alumina:3-5 % of the weight, and yttria:5-15% of the weight. furthermore, a ratio with the maximum peak B of crystal phases other than the maximum peak A of a silicon nitride by the X diffraction while this cutting tool 1 is equipped with the matrix phase which consists of a silicon nitride, the hard phase which consists of a titanium nitride, the glass phase which exists in a grain-boundary phase, and the crystal phase which exists in a grain-boundary phase, a silicon nitride, and a titanium nitride -- R (=B/A) is the tool of the range of 0.05<=R<=0.6
[0031] b) Next, explain the manufacture method of the cutting tool 1 of this example. Weighing capacity of the silicon-nitride (Si_3N_4) powder (more than rate =of alpha99%) of the principal component of 0.5 micrometers of mean particle diameters, the yttria (Y_2O_3) powder of 0.8 micrometers of mean particle diameters, and the alumina (aluminum 2O3) powder of 0.4 micrometers of mean particle diameters is carried out to the blending ratio of coal (example of this invention) shown in the following table 1 so that it may become the composition range of the aforementioned cutting tool 1.
[0032] Next, using the ball made from an alumina, and the wall pot made from an alumina, wet-blending trituration is carried out in an ethanol solvent for 16 hours, and let this material that carried out weighing capacity be a slurry. Next, water-bath dryness of this slurry is carried out, the organic binder of a micro wax system which dissolved in ethanol is added 3.5% of the weight by the solid-content ratio, and it mixes with a RAIKAI machine.
[0033] Next, after carrying out press forming of the acquired base so that it may become ISO specification:SNGN120408 configuration, in the nitrogen atmosphere set as one atmospheric pressure, it heats at 800 degrees C for 60 minutes, and a ** wax is performed. Next, primary sintering is performed. This primary sintering sinters by heating for 4 hours at 1700 degrees C in the nitrogen atmosphere of an ordinary pressure (one atmospheric pressure).
[0034] Next, gas ****** performs secondary sintering. In the nitrogen atmosphere set as 75 atmospheric pressure, this secondary sintering is heated at 1750 degrees C for 4 hours, may be replaced with that it is what sinters, in addition gas ****** of this secondary sintering, and may perform sintering by HIP. Secondary sintering by this HIP sinters by heating for 4 hours at 1700 degrees C in the nitrogen atmosphere set as 1000 atmospheric pressure.
[0035] Next, on conditions (example of this invention) as show the nature sintered compact of a silicon nitride obtained by making it this appearance in the following table 1, it heat-treats in nitrogen atmosphere and crystallization of a grain-boundary phase is promoted. Next, a cutting tool 1 is completed by carrying out the grinding process of this silicon-nitride sintered compact to ISO

specification:SNGN120408 configuration.
[0036] c) Next, explain the example of an experiment which went to the well which checks the effect of the cutting tool of the range of this invention. First, the cutting tool of the example of this invention (sample No.1-4) and the example of comparison (sample No.5-10) was produced on the conditions shown in the following table 1 as a cutting tool used for an experiment. In addition, the configuration of a cutting tool is ISO specification:SNGN120408.
[0037] And the (following i) physical property ability evaluation and (ii) cutting-ability ability evaluation were performed to these cutting tools of sample No.1-10.
(-- i) <physical property ability evaluation> -- the kind of the density of a sintered compact, a micro pore, a degree of hardness, toughness, the peak ratio R (the amount of crystal phases), and crystal phase was searched for as follows The result is described in the following table 1.
[0038] ** (Density)
The density of a sintered compact was measured by the Archimedes method. And it asked for the theoretical density ratio of a sintered compact from the density. Moreover, the micro pore carried out mirror polishing of the sintered-compact cross section, observed it under the 200 times as many microscope as this, and was measured by CIS-006B specification.
[0039] ** (A degree of hardness and toughness)
Mirror polishing of the field as for which the sintered compact carried out grinding was carried out, the Vickers indenter was pushed in by the 30kg pushing load, the diagonal length and the crack length of an indentation were measured, and Vickers hardness (based on JIS R1610) and the fracture toughness value (based on JIS R1607 (the IF method)) were calculated.
[0040] ** ((R) Peak ratio (the amount of crystal phases))
The X diffraction over the polished surface of a sintered compact was performed, and it asked for the peak ratio R. For example, when an X diffraction as shown in drawing 3 is acquired, the maximum peak B (=I (GB max)) of crystal phases other than the maximum peak A of a silicon nitride (=I (Si3N4 max)), a silicon nitride, and a titanium nitride is measured, and it asks for the peak ratio R (=B/A=I(GB max)/I (Si3N4 max)).
[0041] In addition, drawing 3 is a graph as a result of the X diffraction which took intensity [cps] along the vertical axis and took 2theta [**] along the horizontal axis, and the peak ratio R is 0.48 in drawing 3 .
** (Kind of crystal phase)
Moreover, the kind of crystal phase was investigated by making each peak acquired according to the aforementioned X diffraction contrast with the peak of a known material, and investigating it.
[0042] (ii) As shown in <cutting-ability ability evaluation> drawing 4 , it machined by moving a cutting tool in the direction of arrow A on condition that the following to the front face by the side of the outer diameter of the rotating cylindrical shape-like **-ed material. And the wear state (frank abrasion loss after an one pass) of the tool edge of a blade in that case and the generating situation of KAKE were investigated. The result is described in the following table 1.
[0043] (Cutting conditions)
**-ed material quality-of-the-material: -- **-ed [Inconel 718] material configuration: -- outer-diameter phi300mmx length a cutting speed of 100mm : V=300 m/min feed per revolution : f=0.15 mm/rev -- cutting deeply : d= 1.0mm dryness and moisture : WET [0044]
[Table 1]

		本発明品				比較例					
試料No.		1	2	3	4	5	6	7	8	9	10
配合組成[重量%]	Si_3N_4	83	75	70.5	60	88	55	75	75	85	68
	Al_2O_3	3	5	3.5	5	3	5	5	5	2	6
	Y_2O_3	4	5	11	15	4	15	5	5	3	16
	TIN	10	15	15	20	5	25	15	15	10	10
焼結方法		①	①+②	①+②	①+③	①	①+③	①	①	①	①
焼結体の成相	Si_3N_4	○	○	○	○	○	○	○	○	○	○
	TiN	○	○	○	○	○	○	○	○	○	○
	結晶相	J, A Uk	J Uk	J Uk	J, H Uk	J Uk	J Uk	J Uk	J Uk	J, A Uk	J Uk
	ﾋﾟｰｸ比 R	0.07	0.3	0.45	0.52	0.3	0.3	0.02	0.7	0.06	0.55
物理特性	理論密度比	99.7	99.6	99.8	99	99.6	99.8	99.6	99.8	94	99.8
	ﾏｲｸﾛﾎﾟｱ	A2	A2	A2	A2	A2	A2	A2	A2	A8	A2
	硬度Hv	15.5	15.5	15	14.8	16	14	15	16.5	14.0	14
	靭性Kc	6.8	6.2	6.7	6	7.3	5.2	6.2	5	5.0	6.5
切削性能	摩耗量[mm]	0.3	0.2	0.1	0.1	1.6	ﾁｯﾋﾟﾝｸﾞ	0.8	ﾁｯﾋﾟﾝｸﾞ	ｶｹ	0.9

[0045] In addition, in the composition phase of a sintered compact, O of Si3N4 shows existence of a matrix phase, and O of TiN shows existence of a hard phase in the aforementioned table 1. Moreover, H A J which shows J phase of a crystal phase indicates Y8Si4N 4O14 and an A phase to be indicates 4 and H phase to be 3O18Ns of Y10aluminum2Si is Y10Si7N4O23, and Uk is a strange phase.
[0046] Furthermore, in addition to primary sintering, that with which ordinary-pressure sintering and ** are HIPs and ** of the sintering method indicates gas ****** and ** to be for them by + performs secondary sintering. In addition, in the sintering method of sample No.7, quick cooling was performed and maintenance was heat-treated at 1400 degrees C by the sintering method of sample No.8 for 12 hours in nitrogen 1 atmospheric pressure.
[0047] Moreover, A2 of a micro pore shows micro pore 0.02 volume %, and A8 shows micro pore 0.6 volume %. the Ming kana from this table 1 -- sample No.1-4 which have the crystal phase of the specified quantity hidden predetermined peak ratio R are [like] excellent in abrasion resistance in the titanium nitride which is an example of this invention Moreover, it has a moderate degree of hardness and moderate toughness, and a chipping does not occur in the case of an experiment, but sample No.1-4 are suitable.
[0048] If there is much abrasion loss when there are too few titanium nitrides (example sample No.of comparison 5), and there are too many titanium nitrides (example sample No.of comparison 6), since it becomes hard, it becomes weak and the edge of a blade chips to it, it is not desirable. Moreover, if there is too little crystallization of a grain-boundary phase (example sample No.of comparison 7), wear will increase, and conversely, if there is too much crystallization (example sample No.of comparison 8), since toughness is insufficient and it results in a chipping, it is not desirable.
[0049] Furthermore, since abrasion resistance is bad when it will be made precise only 94% if there are few sintering acids (example sample No.of comparison 9), but there are many sintering acids (example sample No.of comparison 10), it is not desirable. In addition, it cannot be overemphasized by this invention that it can carry out in various modes in the range which is not limited to the aforementioned example at all and does not deviate from the summary of this invention.
[0050]
[Effect of the Invention] composition of four components which mentioned the cutting tool of this invention above as explained in full detail above, the composition of four sorts of phases, and the ratio of a peak -- since it has R, it is the cutting tool which was excellent in abrasion resistance and toughness with moderate composite-izing of a silicon nitride and a titanium nitride, and moderate crystallization of a grain-boundary phase
[0051] Moreover, the cutting tool which has the outstanding performance mentioned above by the manufacture method of the cutting tool of this invention can be easily manufactured by the low cost.

[Translation done.]

JAPANESE [JP,2000-354901,A]

[Translation done.]

JAPANESE [JP,2000-354901,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS EXAMPLE DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

JAPANESE [JP,2000-354901,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS EXAMPLE DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

PRIOR ART

[Description of the Prior Art] Conventionally, many sintered compacts which make a silicon nitride a matrix (base material) are developed. For example, the silicon-nitride hotpress sintered compact containing one sort chosen from a titanium nitride and a tantalum nitride or two sorts is proposed by JP,60-48475,B.
[0003] Moreover, apart from this, the silicon nitride tool which makes a silicon nitride and a charcoal titanium nitride a subject is indicated by JP,9-268071,A, and this kind of silicon nitride tool is used for processing (cutting) of cast iron parts etc.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] composition of four components which mentioned the cutting tool of this invention above as explained in full detail above, the composition of four sorts of phases, and the ratio of a peak -- since it has R, it is the cutting tool which was excellent in abrasion resistance and toughness with moderate composite-izing of a silicon nitride and a titanium nitride, and moderate crystallization of a grain-boundary phase
[0051] Moreover, the cutting tool which has the outstanding performance mentioned above by the manufacture method of the cutting tool of this invention can be easily manufactured by the low cost.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem] (1) Invention of the claim 1 for attaining the aforementioned purpose A silicon nitride is made into a matrix. Titanium-nitride:10-20 % of the weight, alumina:3-5 % of the weight, Yttria : while having the matrix phase which is a cutting tool containing 5 - 15 % of the weight, and consists of the aforementioned silicon nitride, the hard phase which consists of the aforementioned titanium nitride, the glass phase which exists in a grain-boundary phase, and the crystal phase which exists in the aforementioned grain-boundary phase a ratio with the maximum peak B of the aforementioned crystal phases other than the maximum peak A of the aforementioned silicon nitride by the X diffraction, the aforementioned silicon nitride, and a titanium nitride -- R (=B/A) makes a summary the cutting tool characterized by being the range of 0.05<=R<=0.6
[0007] ** Although the cutting tool of this invention is a nature sintered compact of a silicon nitride which makes a silicon nitride a matrix (namely, base material which is a principal component) and titanium-nitride:10-20 % of the weight, alumina:3-5 % of the weight, and yttria:5-15 % of the weight are included in addition to this silicon nitride, the effect that abrasion resistance increases to the matrix of a silicon nitride especially by excelling in thermal conductivity, and making a titanium nitride with little coefficient of friction contain, and composite-izing is acquired.
[0008] Hereafter, the reason of numerical limitation of each component is explained.
< titanium nitride: If the content of a titanium nitride with the high abrasion resistance to 10 - 20 % of the weight > molten metal is less than 10 % of the weight, wear-resistant improvement is not enough, and since there is an inclination for a degree of sintering to fall, on the other hand when it exceeds 20 % of the weight, a titanium nitride is a range with 10 - 20 most desirable % of the weight.
[0009] < alumina: Since a degree of sintering will fall if the content of a 3 - 5 % of the weight > alumina is less than 3 % of the weight, a degree of hardness will fall on the other hand if it exceeds 5 % of the weight, and abrasion resistance deteriorates, an alumina is a range with 3 - 5 most desirable % of the weight.
[0010] < yttria: If it exceeds 15 % of the weight, since a degree of sintering will fall if the content of a 5 - 15 % of the weight > yttria is less than 5 % of the weight, and a crystal phase will increase on the other hand, a yttria is a range with 5 - 15 most desirable % of the weight.
[0011] In addition, when a cutting tool consists only of a silicon nitride, a titanium nitride, an alumina, and a yttria substantially, weight % of a silicon nitride becomes a titanium nitride, an alumina, and the remainder of sum total weight % of a yttria.
** In addition to the composition of the aforementioned composition, by this invention, it has four sorts of phase structures again. That is, they are the matrix phase (base material phase) which consists of a silicon nitride, the hard phase which consists of a titanium nitride, the glass phase which exists in a grain-boundary phase, and the crystal phase which exists in a grain-boundary phase. Although the state of these four phases is typically shown in drawing 1 , a grain-boundary phase exists between a matrix phase and a hard phase, and this grain-boundary phase consists of a glass phase and a crystal phase.
[0012] In this invention, since the amount of glass phases in a grain-boundary phase decreased, even when edge-of-a-blade temperature rises by existence of the crystal phase by crystallization of a part of

this grain-boundary phase, softening of a grain-boundary phase will be reduced and the effect that abrasion resistance improves is acquired as a result.
[0013] ** a ratio with the maximum peak B of crystal phases other than the maximum peak A of a silicon nitride further acquired according to the X diffraction by this invention, a silicon nitride, and a titanium nitride -- R (=B/A) is set as the range of 0.05<=R<=0.6 In addition, the peak in a crystal phase is included in a crystal phase, for example, shows the amount of a known crystal like [Y8Si4N 4O14 and 3O18Ns of Y10aluminum2Si] 4 and Y10Si7N 4O23, or a strange crystal.
[0014] and the ratio of the aforementioned peak -- the effect that there will be too few amounts of a crystal phase and they will suppress softening of the aforementioned grain-boundary phase if R is less than 0.05 -- few -- abrasion resistance -- a low On the other hand, if the ratio R of a peak exceeds 0.6, there will be too many amounts of a crystal phase and toughness will fall. therefore, the ratio of the aforementioned peak -- R is a range with most desirable 0.05<=R<=0.6
[0015] that is, composition of four components which mentioned this invention above, the composition of four sorts of phases, and the ratio of a peak -- since it has R, it is the cutting tool excellent in abrasion resistance and toughness
(2) Invention of a claim 2 makes [the aforementioned crystal phase] the cutting tool of a publication a summary at the aforementioned claim 1 characterized by including J phase.
[0016] this invention illustrates the composition of a crystal phase and contains J phase, i.e., Y8Si, 4N 4O14 as a crystal phase. Therefore, since the glass phase of a grain-boundary phase decreases and it becomes the high crystal of the melting point, it is effective in softening of the grain-boundary phase in an elevated temperature being suppressed.
(3) Invention of a claim 3 makes a summary the aforementioned claim 1 characterized by the aforementioned cutting tool being an object for cutting of a superalloy, or a cutting tool given in 2.
[0017] this invention illustrates the use of a cutting tool. That is, by this invention, although thermal conductivity of a superalloy is bad and the edge of a blade of a cutting tool tends to be filled with heat, since it has the composition mentioned above, even when carrying out cutting of the superalloy and edge-of-a-blade temperature rises, softening of a grain-boundary phase is suppressed and the outstanding abrasion resistance can be demonstrated.
[0018] Here, a superalloy is usually an alloy which is equal to the use in an elevated temperature of 650 degrees C or more, and, specifically, are things, such as an alloy of a high temperature service with which Fe component of alloy composition makes a principal component the thing of alloy [50 or less % of the weight of], nickel, and Co system. As this superalloy, the Inconel of nickel machine alloy, WASUPAROI, etc. are mentioned, for example.
[0019] In addition, the cutting tool of this invention is especially desirable although nickel machine alloy (an Inconel, WASUPAROI) mentioned above is cut. As these cutting conditions, the following range is suitable.
Cutting speed : V= 100 - 500 m/min (preferably 200 - 400 m/min)
Feed per revolution : f= 0.05 - 0.4 mm/rev (preferably 0.1 - 0.3 mm/rev)
Infeed : d= 0.05mm or more (preferably 0.1mm or more)
(4) Let the cutting tool of a publication be a summary at either of the aforementioned claims 1-3 to which invention of a claim 4 is characterized by the aforementioned cutting tool having a cutting edge between a rake face and a flank.
[0020] this invention illustrates the configuration of a cutting tool and for example, the rectangular parallelepiped configuration equipped with the cutting edge between the rake face and the flank is mentioned. Moreover, the thing of various kinds of configurations, such as the shape of a square pilaster of a rhombus and the shape of a cylindrical shape with a circular rake face side triangular triangle pole configuration and rake face side, is mentioned for a rake face side besides it.
[0021] (5) Invention of a claim 5 is the manufacture method of a cutting tool given in either of the aforementioned claims 1-4, and makes a summary the manufacture method of the cutting tool characterized by performing ordinary-pressure sintering in nitrogen atmosphere. Since this invention can manufacture the nature sintered compact of a silicon nitride by illustrating the manufacture method of a

cutting tool, fabricating the material adjusted here so that it might become the composition of composition of the aforementioned cutting tool etc., and carrying out ordinary-pressure sintering in nitrogen atmosphere, let it be a cutting tool by performing post processing, such as after that, for example, polish etc.
[0022] This ordinary-pressure sintering has the advantage that manufacture is easy compared with HIP, and a manufacturing cost is low, therefore a cutting tool can be manufactured at low cost. In addition, when manufacturing the nature sintered compact of a silicon nitride suitable for the cutting tool only by ordinary-pressure sintering, it is necessary to choose appropriately composition (therefore, composition of a cutting tool) of the material. It is desirable to specifically choose material from which composition of a cutting tool serves as less than [TiN:10 % of the weight], more than sintering-acid:6 % of the weight, and remainder:Si3N4.
[0023] (6) Let the manufacture method of the cutting tool a publication be a summary at the aforementioned claim 5 characterized by invention of a claim 6 performing gas ****** in nitrogen atmosphere after the aforementioned ordinary-pressure sintering. cases other than specific composition -- usually -- ordinary-pressure sintering (primary sintering) -- accepting it -- coming out -- as a cutting tool -- enough -- precise-izing -- since a sintered compact is hard to be obtained the bottom (for example, 95% or less of a theoretical density ratio), in this invention, gas ****** is performed in nitrogen atmosphere as secondary sintering Thereby, the sintered compact which fully turned precisely is obtained (for example, a theoretical density ratio 98% or more).
[0024] Thus, the sintered compact which fully turned precisely can be manufactured by the low cost by combining ordinary-pressure sintering and gas ******. In addition, as conditions for gas ******, although nitrogen atmosphere is adopted, the pressure of the nitrogen atmosphere is five to 100 atmospheric pressure, and the range of burning temperature of 1600-1800 degrees C is desirable.
[0025] (7) Let the manufacture method of the cutting tool a publication be a summary at the aforementioned claim 5 characterized by invention of a claim 7 performing sintering by HIP (Hot Isostatic Press : hot isostatic press) after the aforementioned ordinary-pressure sintering.
[0026] it mentioned above -- as -- usually -- ordinary-pressure sintering (primary sintering) -- accepting it -- coming out -- as a cutting tool -- enough -- precise-izing -- since a sintered compact is hard to be obtained the bottom, in this invention, sintering by HIP is performed as secondary sintering Thereby, the sintered compact which fully turned precisely is obtained (theoretical density ratio 95% or more).
[0027] Thus, the sintered compact which fully turned precisely can be manufactured by combining ordinary-pressure sintering and sintering by HIP. In addition, as conditions for sintering by HIP, although nitrogen atmosphere is adopted, the pressure of the nitrogen atmosphere is 1000 to 2000 atmospheric pressure, and the range of burning temperature of 1500-1800 degrees C is desirable.
[0028]
[Embodiments of the Invention] The cutting tool of the following and this invention, and the example of the gestalt of operation of the manufacture method

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[Translation done.]